ikom - ComNets

Master Thesis Presentation

Virtual Network Interoperability in the Future Internet

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Motivation

- Current Internet doesn't provide enough facilities to deploy, manage and operate new network models
- Many initiatives have been taken to design the "Future Internet"
- Network virtualization will play an important role in Future Internet

What is Network Virtualization?

- Network Virtualization is *"the process of combining hardware and software network resources and network functionality into a single, software-based administrative entity .Network virtualization involves platform virtualization, often combined with resource virtualization …"* Wikipedia definition

- Network virtualization allows deployment of innovative network designs

- Maximum utilization of network resources
  - e.g. Router, Server, Link

Network Virtualization and 4WARD Project

- 4WARD is a European founded project
  - 23.25 million euro budget
  - about 36 Partners
    - Universities and Industrial companies.
- Objective:
  - Make the development of networks and network related services and applications faster and easier
- Network Virtualization is one of the 6 paradigms of 4WARD (WP3)
- How to allow multiple virtual networks (VNets) with different architecture to co-exist using network virtualization

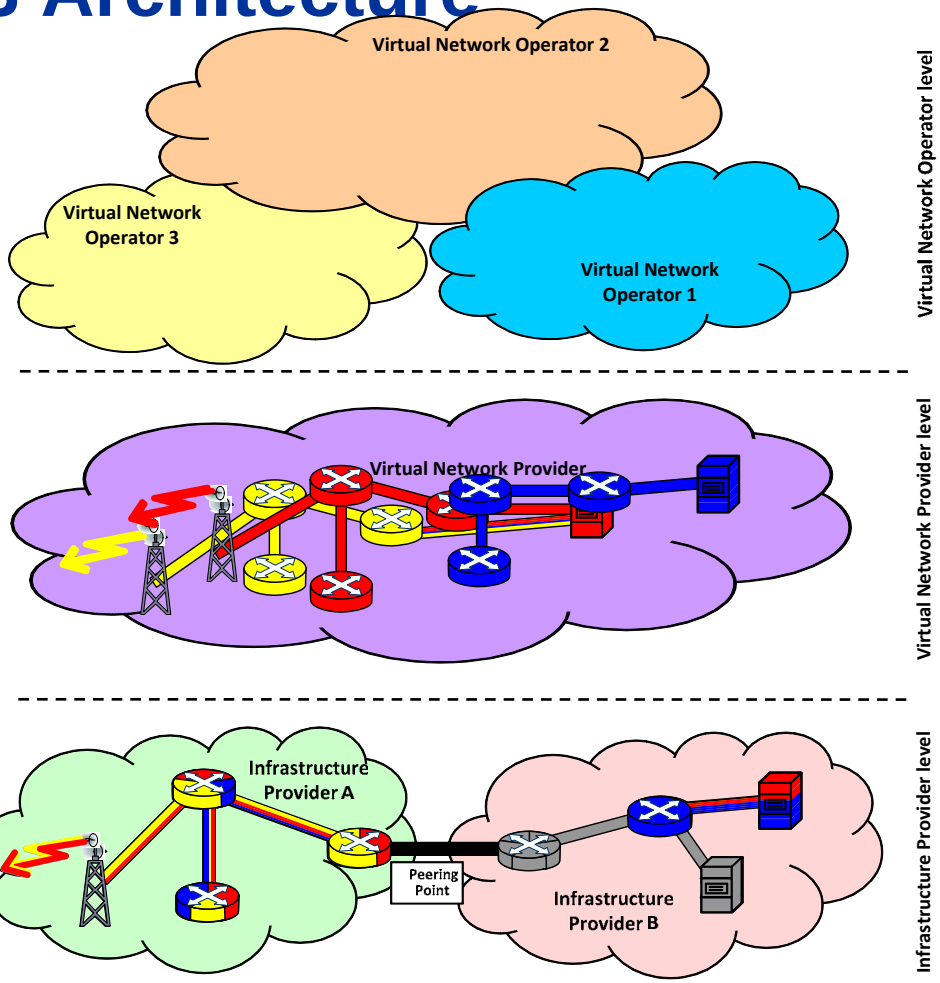
4WARD-WP3 Architecture

WP3 architecture uses virtualization as a tool to divide today's Internet Service Providers (ISPs) into separate entities so as to open the way for new business roles and models, basically into:

Infrastructure Providers: these are the owners of the physical resources, they run and maintain the physical nodes and links, and virtualize their resources into virtual ones that are then offered (rented) to the virtual network providers.

Virtual Network Providers: these are kind of brokers that sit in between the Inf. And VNets Operators. There job is setting up virtual networks from different Inf. providers upon requests from VNet(s) Operators and then giving the VNet(s) into the operators.

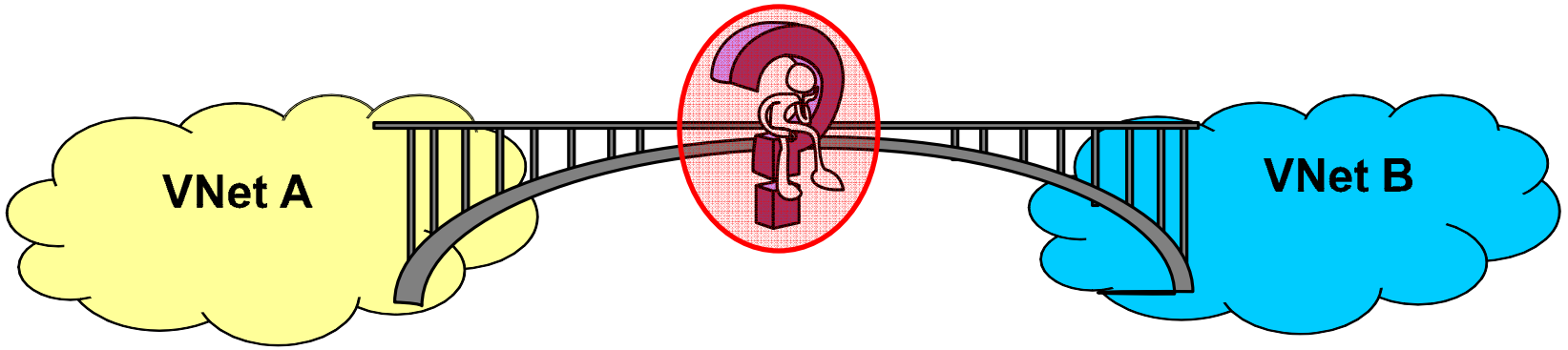
Virtual Network Operators: these are the operators that run the VNets, and offer services to end users. They will have end to end control over their VNets.



Folding Points Motivation

- The outcome of the network virtualization is the co-existence of multiple virtual networks (VNets) on the same physical infrastructure

- By default the VNets are isolated and there is no intercommunication between them

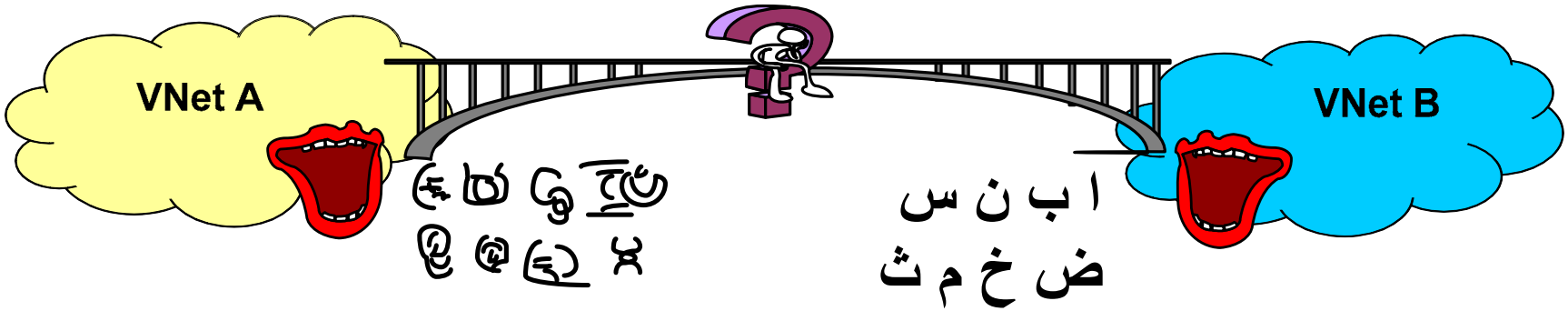


- To allow the communication, there should be some facilities that can enable this special type of communication between VNets

- These facilities are called "Folding Points"

What are Folding Points?

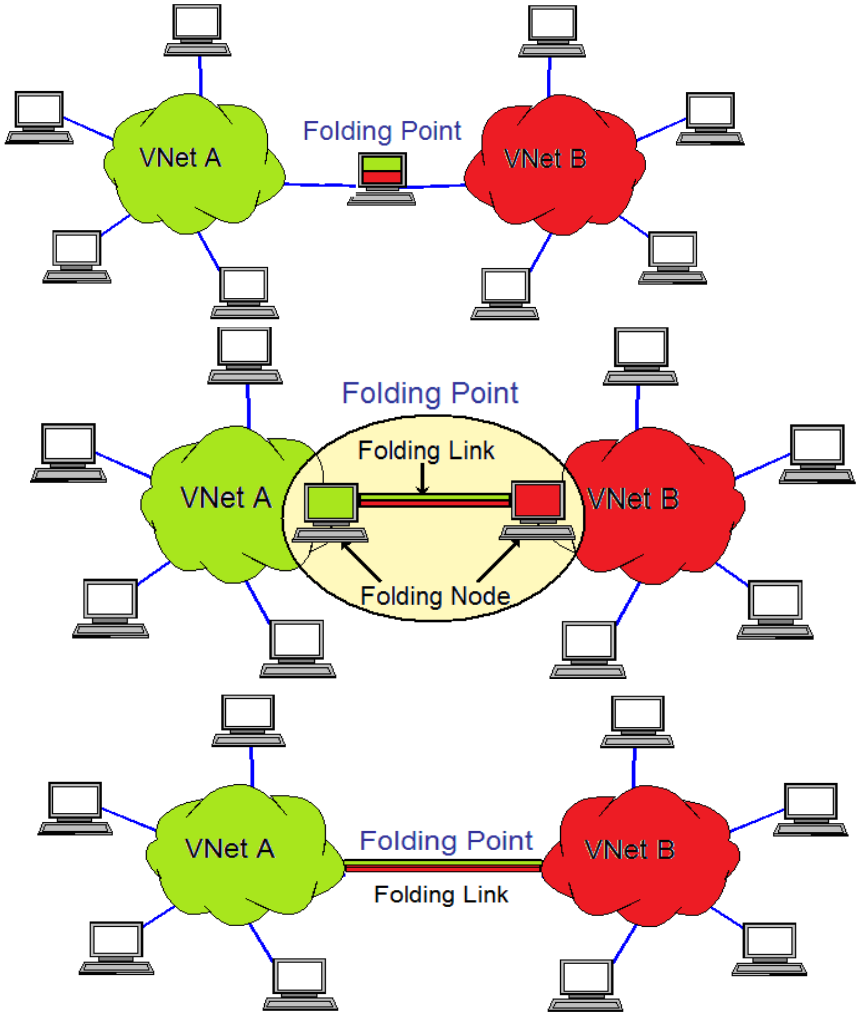
- Folding Points are the enabler of communication between different VNets
- Those VNets could be semantically different in terms of their protocols, architecture, naming and addressing schemes that they are using.



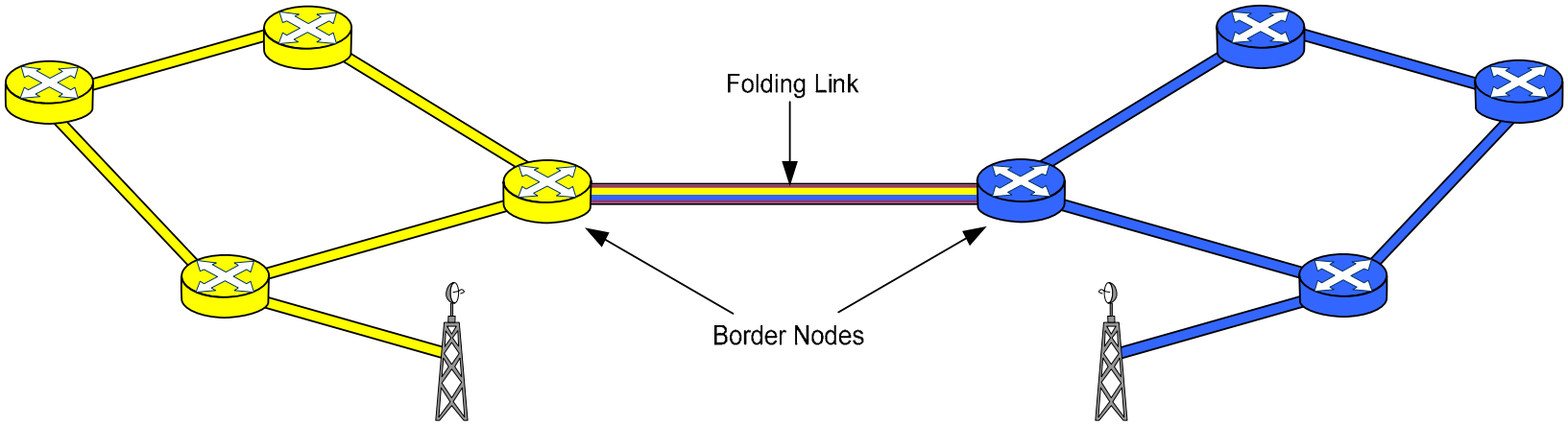
- So what the Folding Points would be responsible for is:
  - Providing a secure connection between the VNets
  - Insuring security in terms of authentication and authorization
  - Policy enforcement at the border of the VNets
  - Translation of protocols: e.g. conversion of naming, addressing and data formats
  - …

Folding Points Basic Elements

- Folding Points in general consists of two basic entities
  - Folding Node (FN): this is a special kind of node that includes the necessary functions of the FP concept: e.g. security, authentication, policy enforcement, translation to connect two networks.
  - Folding Link (FL): this is a special kind of link that connects two VNets. The reason why this link is different from a normal virtual link is that it is part of both VNets and it connects nodes from different Vnets.

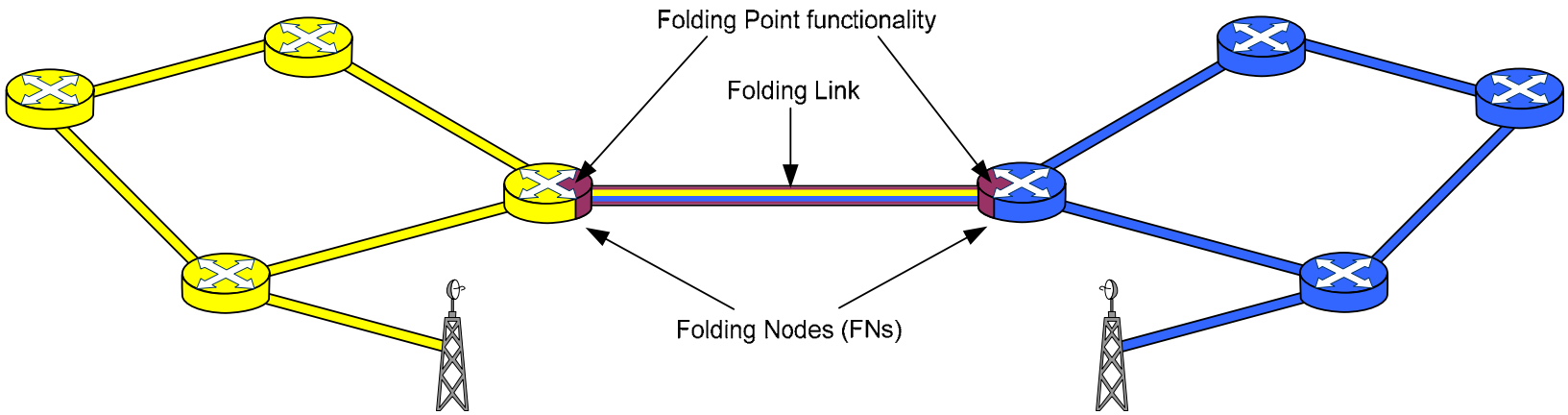


Folding Point Scenario 1



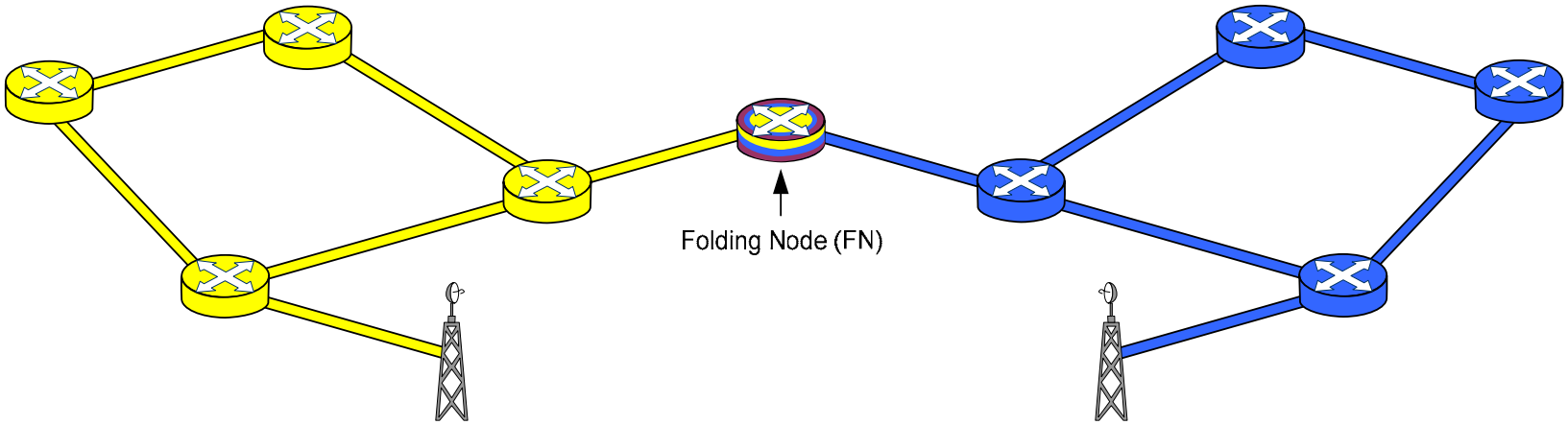
- To Connect two similar VNets (e.g: Ipv4)
- No Protocol/address Translation required.

Folding Point Scenario 2



- The Folding Point in this scenario consists of two FNs and one FL
- Each of the FNs belongs to one VNet, whereas the FL is basically part of both VNets

Folding Point Scenario 3



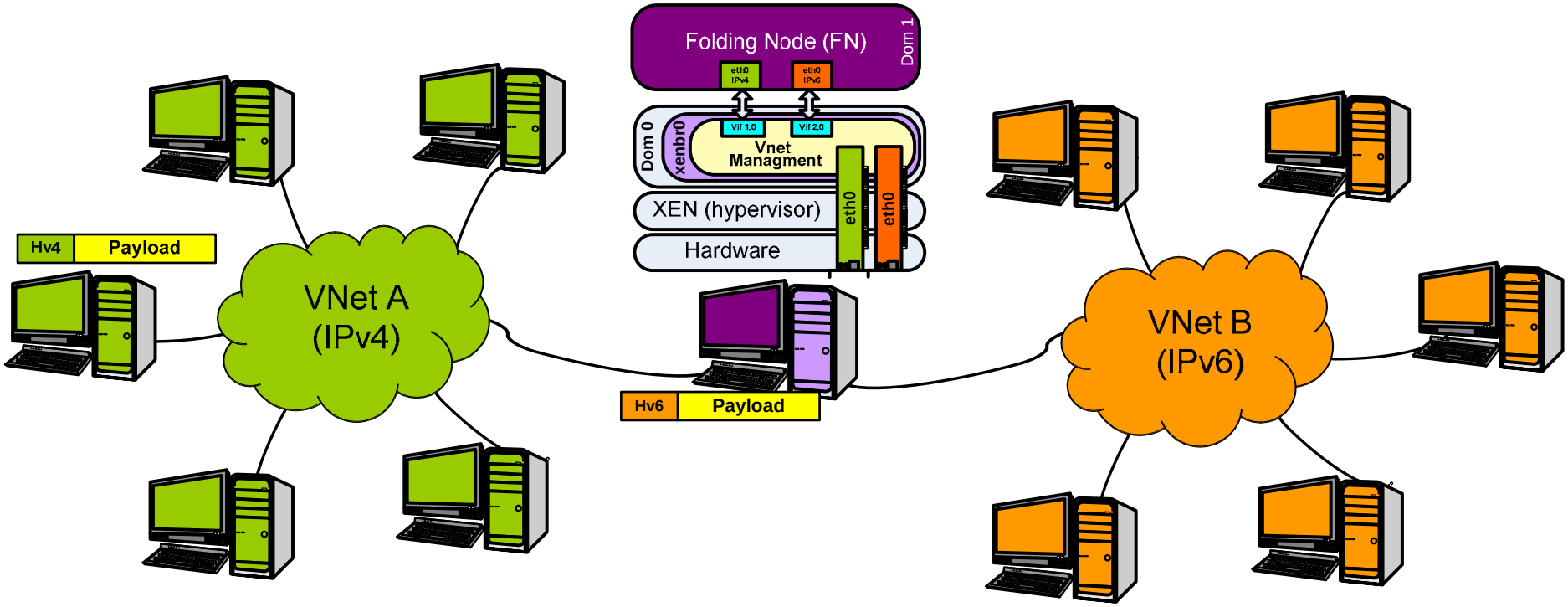
- The FN is instantiated in an external substrate node; this virtual node belongs to both VNets
- In this case there will be no need for a Folding link, but there will be a need for the VNets to extend their virtual links to the FP node

Folding Point Prototype

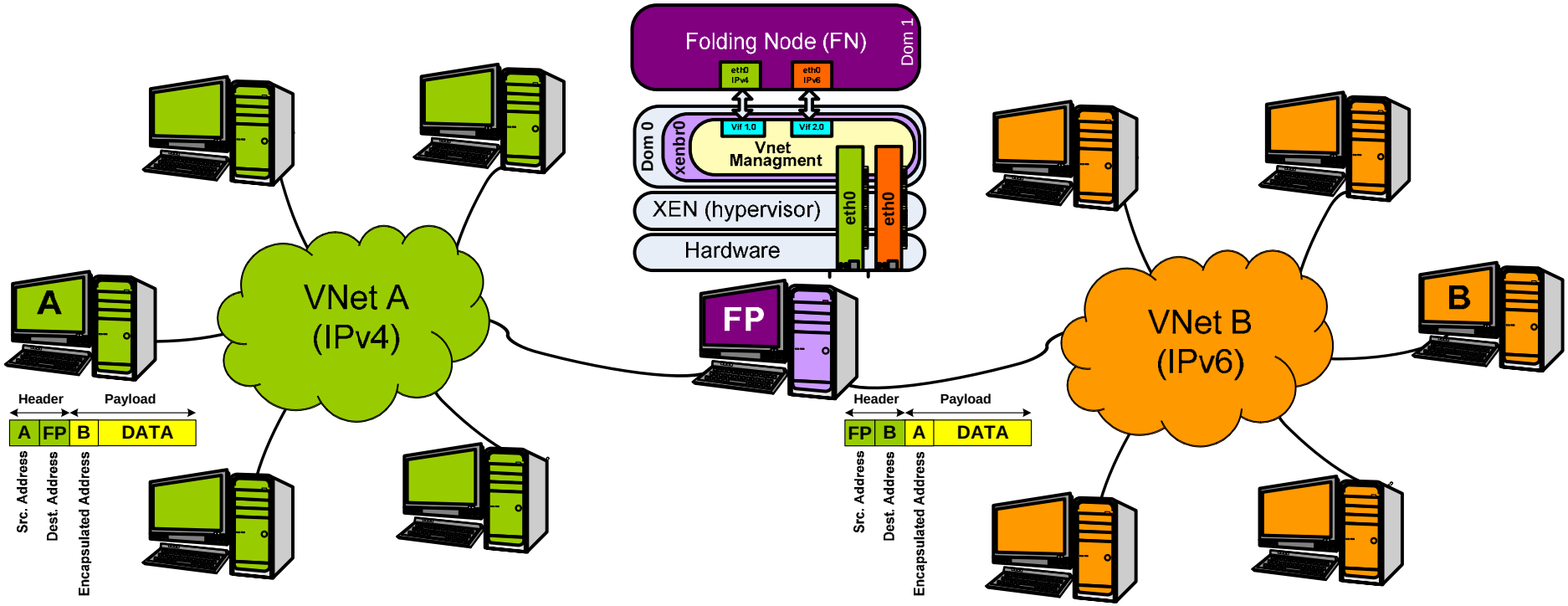
- A Simplified Folding Point was designed and developed to interconnect IPv4 and IPv6 VNets
  - Performs Protocol Translation
  - Address Translation
  - Written in C Programming language using Berkley Socket API
  - Stateless IP/ICMP Translation Algorithm (SIIT)
    - RFC 2765
  - Using the Xen Hypervisor as a virtualization platform
  - Iperf network testing tool to generate traffic
  - VLC player is used for Video Streaming (for demo)

This is only an example (proof of concept), in general the Folding Point Prototype should support any type of translation

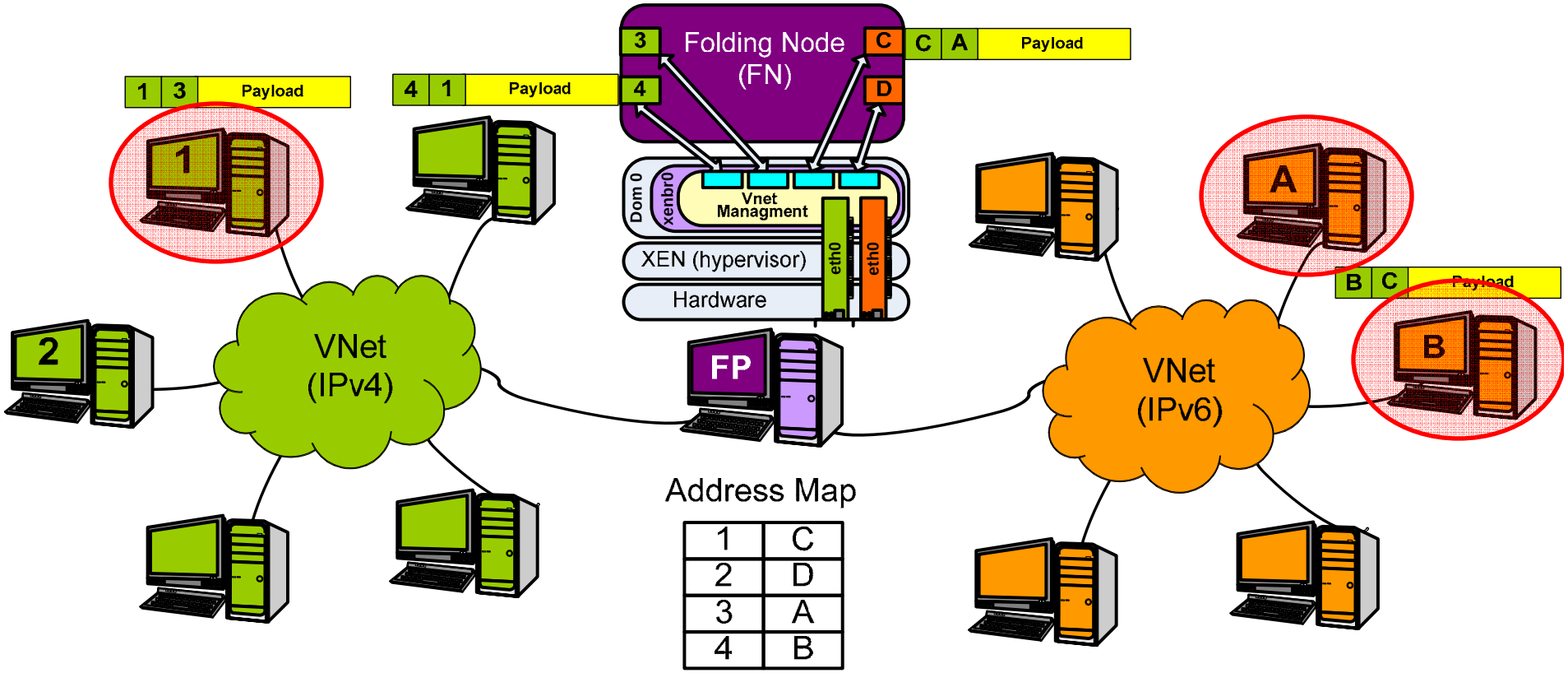
Protocol Translation



Address Encapsulation

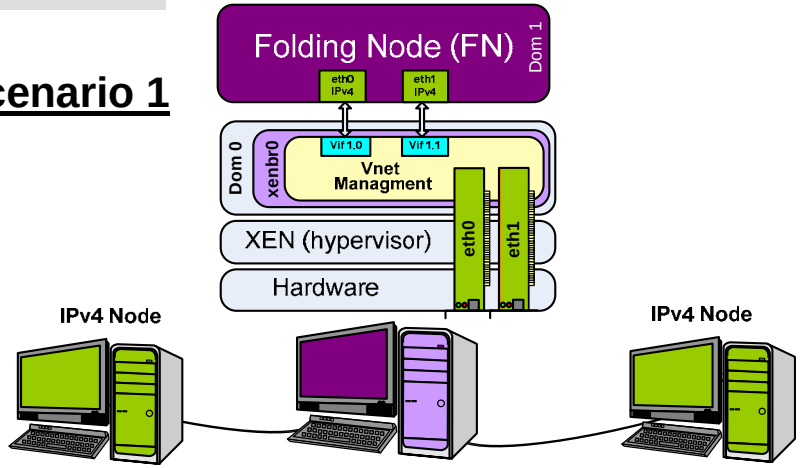


Address Mapping

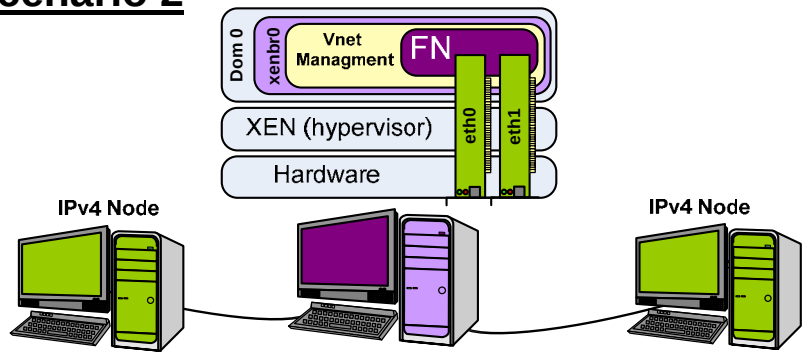


Testbed Scenarios

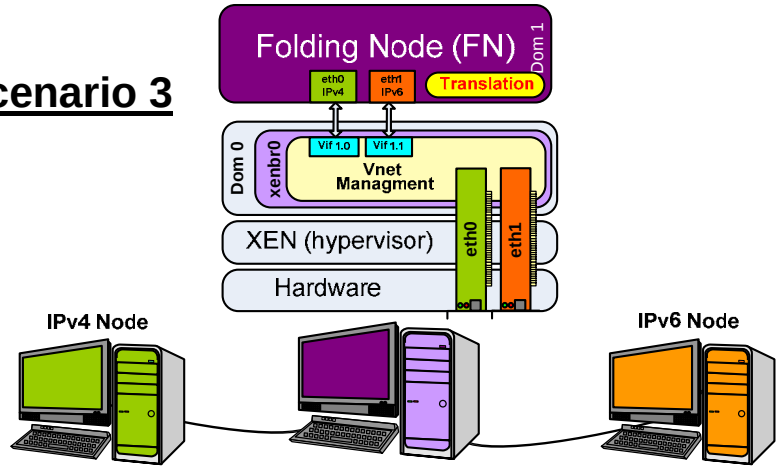
Scenario 1



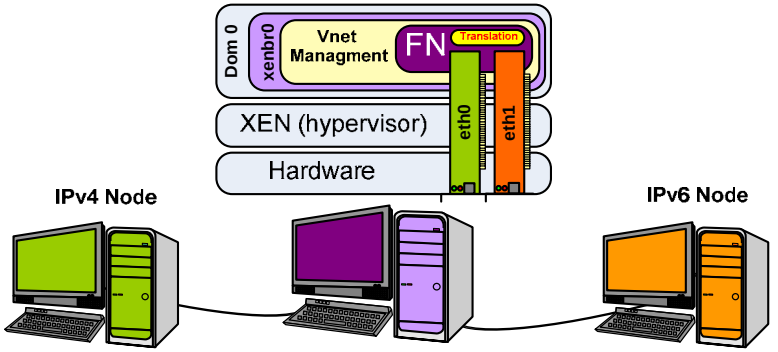
Scenario 2



Scenario 3



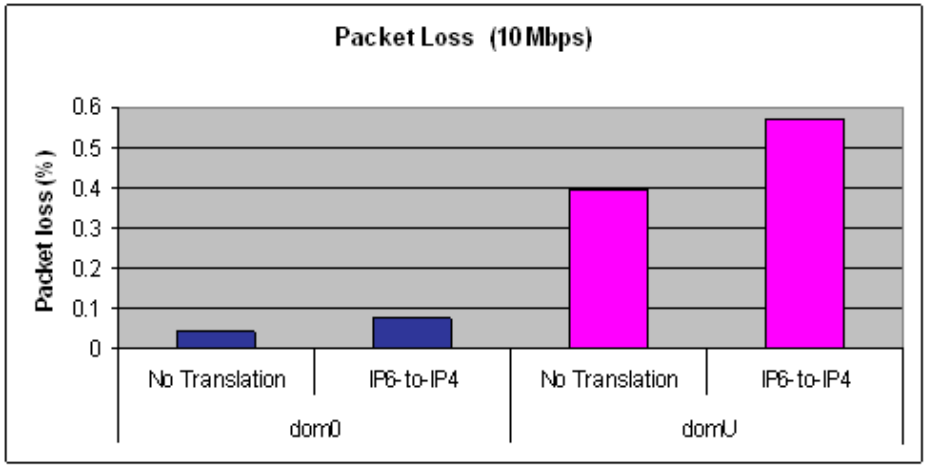
Scenario 4

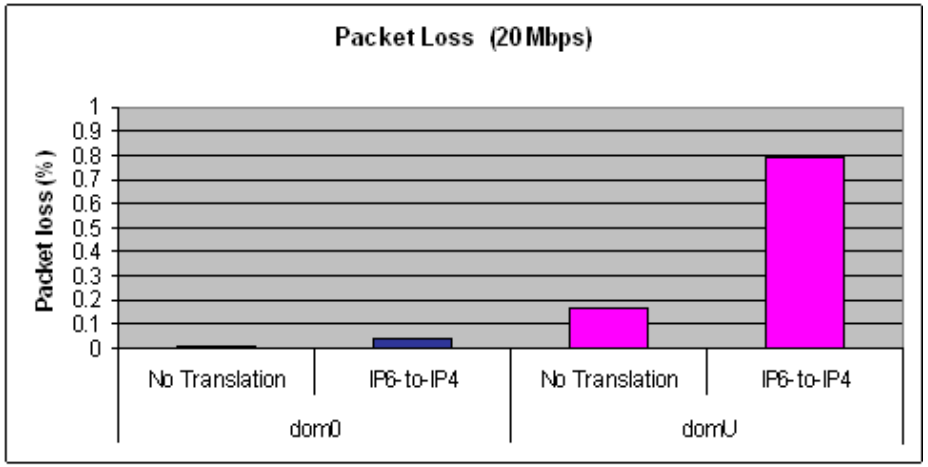


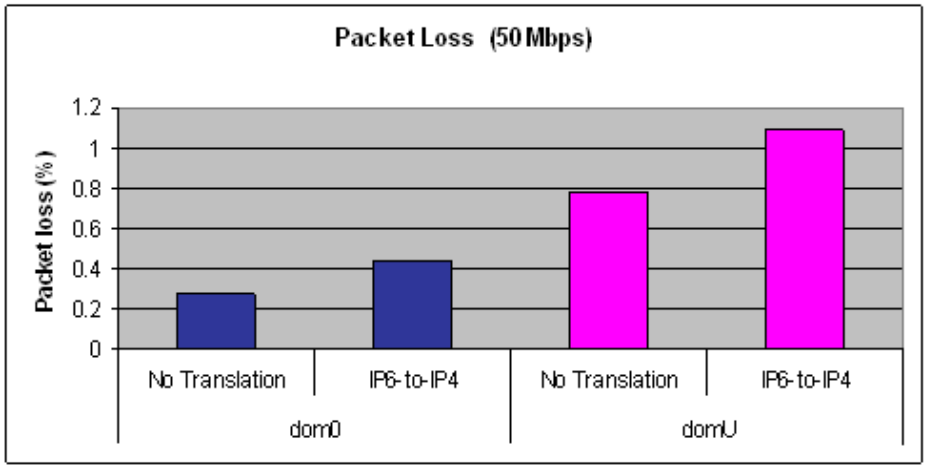
Performance Evaluation Parameters

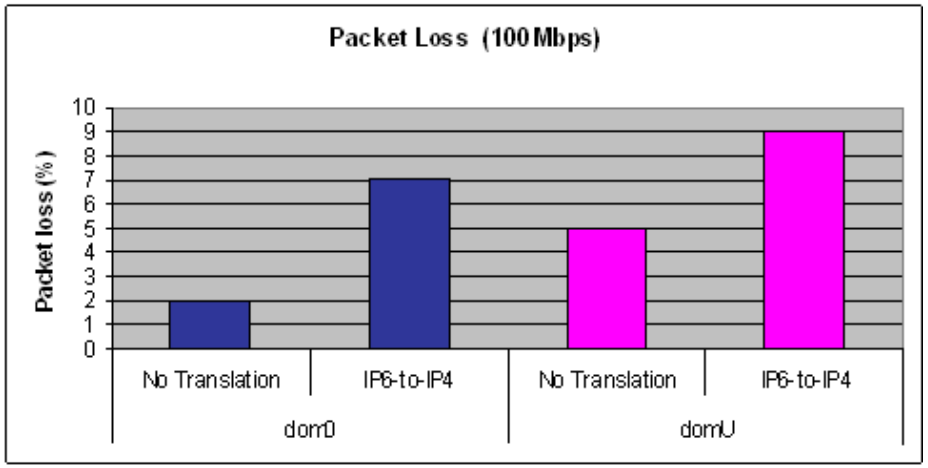
- Parameters
  - Packet Loss
  - Throughput
  - Jitter (Latency variation)
- Iperf UDP Tests
  - 10Mbps, 20Mbps, 50Mbps, 100Mbps
- 500 Test Runs
  - 10 MB data transferred in each Run

Packet Loss

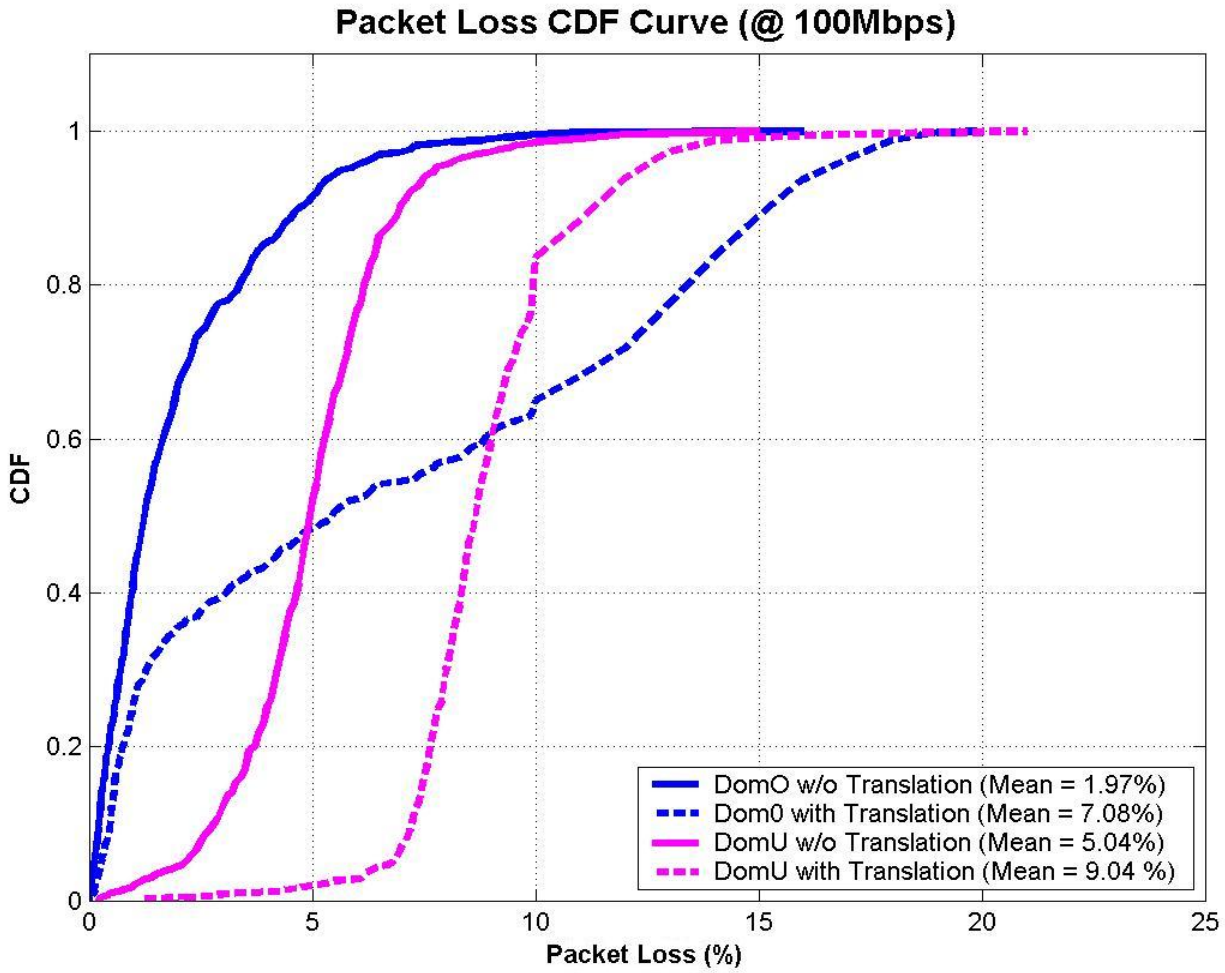

Packet Loss (10 Mbps)
Packet loss (%)
0.6
0.5
0.4
0.3
0.2
0.1
0
No Translation
IP6-to-IP4
No Translation
IP6-to-IP4
dom0
domU


Packet Loss (20 Mbps)
Packet loss (%)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
No Translation
IP6-to-IP4
No Translation
IP6-to-IP4
dom0
domU

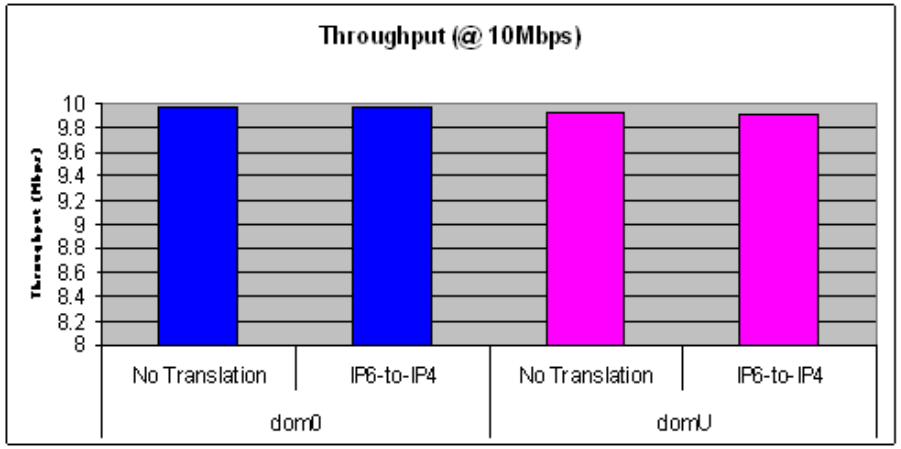

Packet Loss (50 Mbps)
Packet loss (%)
1.2
1
0.8
0.6
0.4
0.2
0
No Translation
IP6-to-IP4
No Translation
IP6-to-IP4
dom0
domU

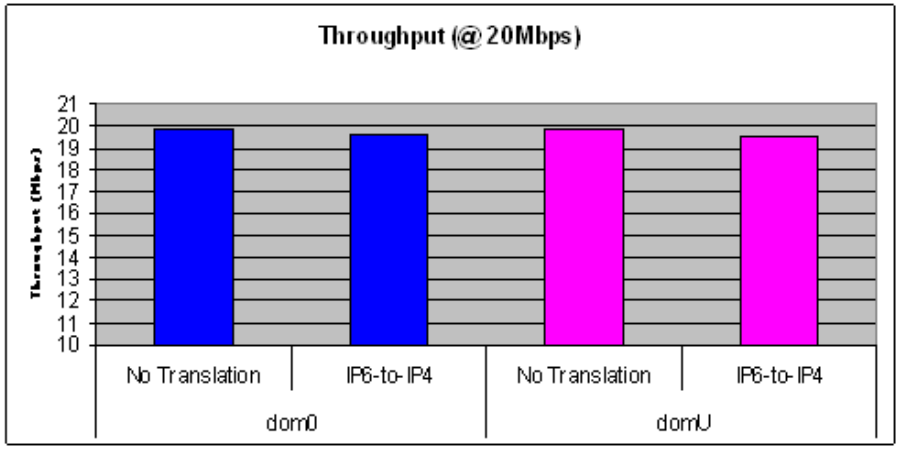

Packet Loss (100 Mbps)
Packet loss (%)
10
9
8
7
6
5
4
3
2
1
0
No Translation
IP6-to-IP4
No Translation
IP6-to-IP4
dom0
domU

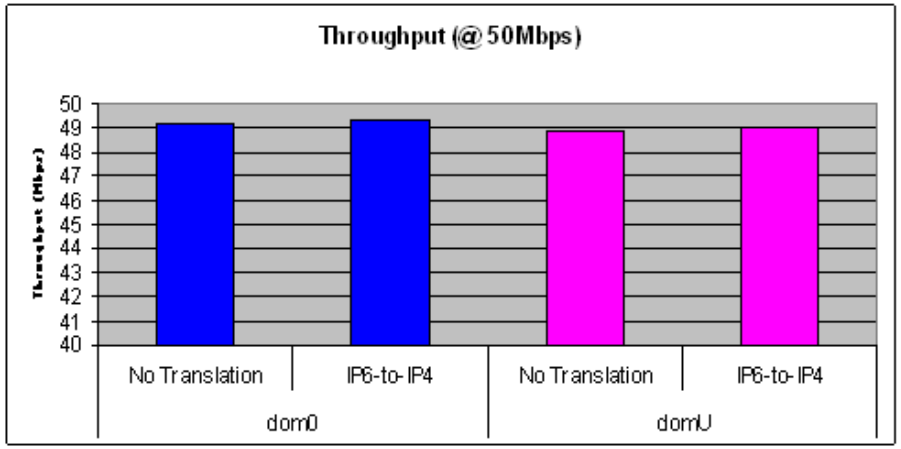
Packet Loss (cont.)

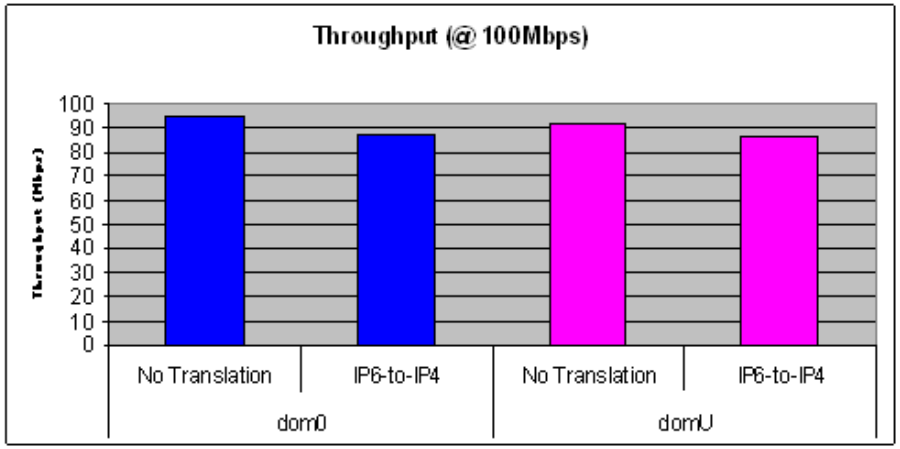


Throughput

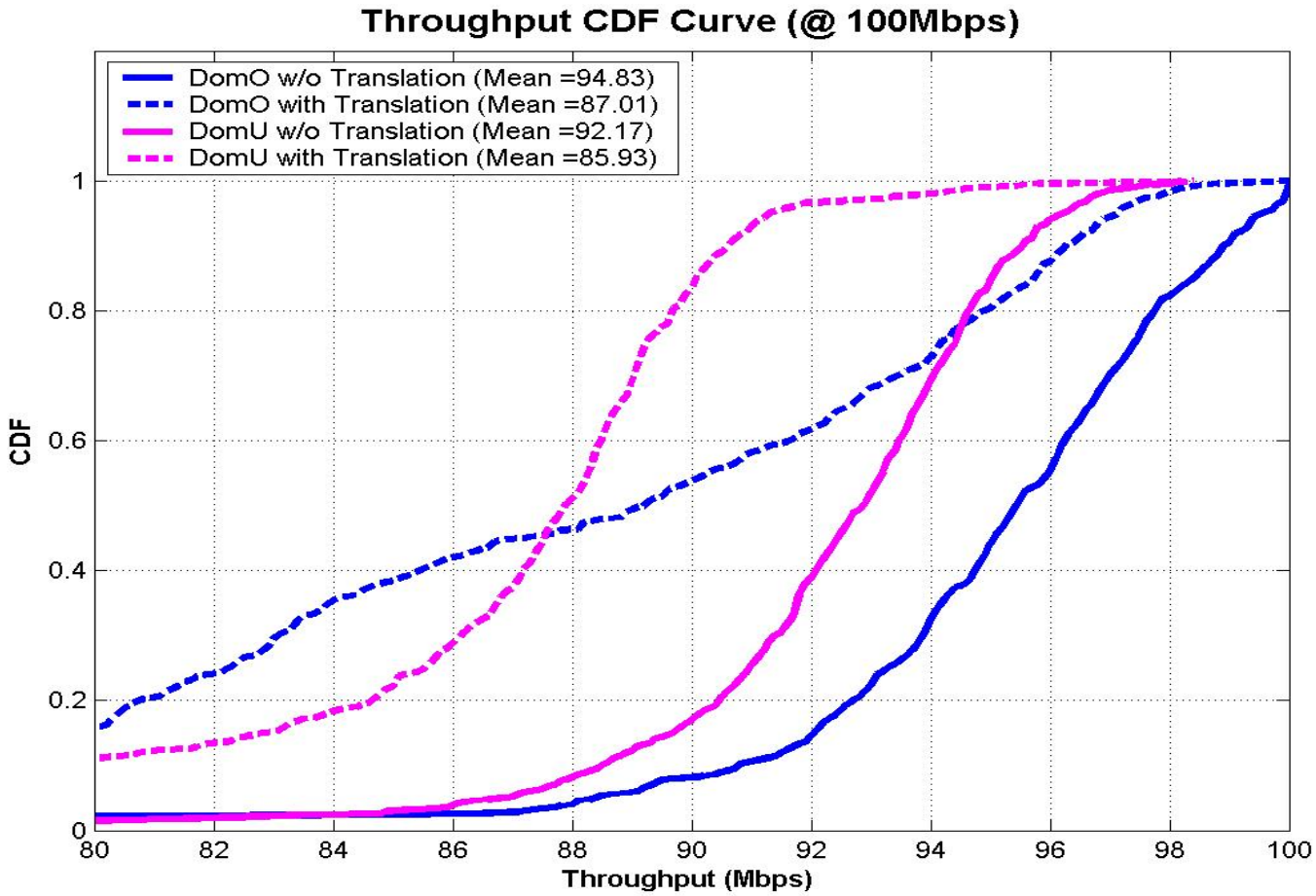

Throughput (@ 10Mbps)
Throughput (Mbps)
10
9.8
9.6
9.4
9.2
9
8.8
8.6
8.4
8.2
8
No Translation
IP6-to-IP4
No Translation
IP6-to-IP4
dom0
domU


Throughput (@ 20Mbps)
Throughput (Mbps)
21
20
19
18
17
16
15
14
13
12
11
10
No Translation
IP6-to-IP4
No Translation
IP6-to-IP4
dom0
domU


Throughput (@ 50Mbps)
Throughput (Mbps)
50
49
48
47
46
45
44
43
42
41
40
No Translation
IP6-to-IP4
No Translation
IP6-to-IP4
dom0
domU


Throughput (@ 100Mbps)
Throughput (Mbps)
100
90
80
70
60
50
40
30
20
10
0
No Translation
IP6-to-IP4
No Translation
IP6-to-IP4
dom0
domU

Throughput (cont.)



Testbed Results

- The FN performs better when located at Dom0 as compared to DomU, the reason is the additional delay that is caused by XEN, since all DomU's traffic is routed through Dom0
- By moving the FN to Dom0 this additional routing is avoided
- In the current translation module implementation no packet buffering is assumed, which is the reason why the packet loss rate is increased when using the translation module
- The results show that the performance is reduced when using the translation module because of the additional delay as the packets have to go all the way up to the user level to be translated

Conclusion

- **The interoperability between virtual networks is one of the crucial issues in the design of Future Internet**
- **The Folding Point concept is proposed to enable interconnection among VNets**
- **Our first testbed evaluation proved that the Folding Points can achieve the goals of the interconnection between different VNets with acceptable performance**
- **Folding Points are not just gateways in disguise they are more than that. What differentiates Folding Points from normal gateways is:**
  - They connect two VNets that are running different architectures/protocols and addressing schemes
  - The dynamic aspects of the Folding Points also make them unique, where Folding Point could be instantiated and deployed on demand and they can be destroyed as well
  - The functions they support could also be changed dynamically during runtime
  - They can be migrated from one node to another
- **Folding Points can play an important role in the migration phase between the current and the Future Internet**

Future Work

- Integrating Folding Point with Click[1] Modular Router (done)
- Design of Folding Point for protocols other than IPv4,IPv6
  - e.g. Translation module between:
    - IP and Sensor Networks
    - IP networks and NetInf[1]

[1] The Click modular router. Eddie Kohler. Ph.D. thesis, MIT, November 2000. http://pdos.csail.mit.edu/papers/click:kohler-phd/thesis.pdf

[2] NetInf is an information centric paradigm currently being developed within 4WARD, the concept focuses on information objects rather than the traditional client-server model. More details can be found in D-6.1 First NetInf architecture description, http://www.4ward-project.eu/index.php?s=publications

Demo

IPv6 Streaming Server

(VLC Player)

IPv4 Streaming Client

(VLC Player)

Folding Point

(IPv6-to-IPv4 Translator)

Dom0/DomU

beef::10

10.0.0.100

IPv6

beef::1

IPv4

10.0.0.1

References

[1]. UNIX® Network Programming Volume 1, Third Edition: The Sockets Networking API By W. Richard Stevens, Bill Fenner, Andrew M. Rudoff

[2]. Yasir Zaki, Liang Zhao, Javier Jimenez, Khalid Mengal, Andreas Timm-Giel and Carmelita Görg: "Towards Interoperability among Virtual Networks in the Future Internet". ICT-MobileSummit 2009, Santander Spain, June 10 - 12, 2009 (Submitted)

[3]. E. Nordmark (Sun Microsystems): “Stateless IP/ICMP Translation Algorithm (SIIT)”. RFC2765, February 2000

[4]. Iperf Site at Sourceforge www.sourceforge.net/projects/iperf

[5]. VLC Media player http://www.videolan.org/vlc/

[6]. E. Nordmark (Sun Microsystems): “Stateless IP/ICMP Translation Algorithm (SIIT)”. RFC2765, February 2000.

Q & A